Tracking Vaccine Compliance in a Primary Care Setting: Online History, Reminders, Order Entry, and Charting

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ABSTRACT

In a new primary care setting with three medical disciplines participating, a vaccine history and order entry system was implemented along with other online documentation systems as the primary documentation tools for the clinic. Reminders were generated based upon a set of algorithms consistent with 1998 nationally accepted vaccine guidelines. Vaccine compliance data were analyzed for the entire population cared for in this setting for a 6 month period. Rates of compliance with national recommendations for eight key vaccine groups were calculated based on the online data. Trends in the rates of compliance, interpreted within limitations, showed statistically and clinically significant improvements. The immunization application accomplished several goals: accurate history and patient-specific recommendations, online ordering of vaccines or serum products, online charting of administration that, in turn, automatically maintained the vaccine history.

INTRODUCTION

The Family Care Center (FCC) of the University of Iowa Hospitals and Clinics (UIHC) opened July 1, 1998 as the outpatient primary care setting for three medical disciplines: Family Medicine, General Pediatrics, and General Medicine. Operations of the FCC were designed around interdisciplinary cooperation among the three services, fully utilizing all existing components of the UIHC online patient record, INFORMM Patient Record (IPR), a Windows-based application developed at the UIHC. IPR included structured documentation of most of the summary components of the record (Allergies, Immunization History / Vaccine Orders / Vaccine Charting, Medications / Prescriptions), most nursing documentation, and all dictated physician narratives. All exam rooms, work rooms, and nursing stations had Windows devices (PCs or network workstations) for access to IPR as well as to a number of Web-based resources.

Nearly all (>99%) vaccine histories, orders, and charting of administration were done online. The few written orders were back-loaded into the system. The immunization application captured immunization history, vaccine orders, and vaccine administration, following the work flow of several disciplines. The targets for use of the immunization application were those services that made the most use of vaccines: primary care (general medicine, general pediatrics, family medicine), renal, pulmonary, infectious disease, and travel medicine. The system was designed with the aid of clinical pharmacists, nurses, physician assistants, advanced registered nurse practitioners, and physicians.

The overall vaccine compliance reported here was one way to analyze the impact of the immunization application on the health care of the patient population cared for by the UIHC FCC. A companion report deals with a randomized study of the impact of online recommendations on the vaccine ordering behavior of physicians[1].

METHODS

The immunization application components included a clinical help file, a rules database, patient historical information, vaccine ordering, charting administration of a vaccine, and reports on patients with recommendations or warnings. In addition to routine health maintenance, the system also supported vaccines for travel medicine and other purposes.

The clinical help file was developed with information derived from several sources[2-4]. Online help described 38 vaccines, serum products, and substances for assessment of immunity. In addition, it contained tables for the normal schedule and the accelerated schedule for children considered behind in immunizations.

To support order entry and online warnings, tables described each of the 38 agents including default information for ordering, the minimum and maximum age at which a particular substance could be used, whether or not a live virus vaccine, a pregnancy category key, and indicators as to the

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presence of egg proteins, yeast proteins, thimerosal, and neomycin.

A rules engine generated automated recommendations for vaccine orders. The specific rules (outlined below) were abstracted from the same sources of clinical information noted above. The rules for scheduling vaccines were reviewed by primary care pediatricians, primary care general internists, and infectious disease specialists. The rules were evaluated based upon a patient's age and history of previous vaccines in order to generate recommendations or warnings.

The accuracy of recommendations depended on an accurate online vaccine history. Historical vaccine information for a ten year period was loaded into the system from UIHC pharmacy billing records. Paper records were reviewed the day prior to planned visits to ensure that vaccines documented on vaccine summary of the paper record were entered online. The nurse interview during the clinical visit supplemented the online history information.

At the time of the visit, physicians reviewed the online history focusing on vaccines important for a given age group. In the case of adults, these included Hepatitis B, Influenza, Pneumococcal, MMR, and Tetanus (Td) vaccine. In the case of pediatric patients, the vaccines were DTaP, Hib, DPT/HIB, Polio, MMR, Varicella, Hepatitis B, DTP, DT, and Tetanus (Td). Next to each was shown an indicator of whether or not the vaccine would be recommended or should be considered based on the history in the table and the rules (Figure 1). The summary also showed any warnings generated regarding any of the vaccines. For instance, if the history indicated that the patient was behind in a vaccine series, a message indicated that the physician should review online guidelines for accelerated vaccinations in the clinical help document. Other messages were shown such as when to schedule the patient back for the next dose. More detail could be viewed, if desired, for history of a given vaccine, alternatives for vaccines available for ordering, recommended doses, and guidelines abstracted from the sources noted above. Whenever a vaccine that contained a live component was recommended or to be considered, a prominent warning was present indicating that it should not be given to women who may be pregnant or to immuno-compromised individuals.

The physician chose whether to override the recommendation of the computer and whether to order additional vaccines. When the order button was selected, the application displayed for all vaccines selected: the name, the form, the manufacturer, brand name, strength, recommended dose (specific for the age and/or weight of the patient), the units, the route, and the recommended site, if any. If other options (such as brand or route) were available for the patient's age, the physician could select among them. The default values for all this information were maintained through review by pharmacy and physicians in pediatric and adult medicine.

The patients went through a check-out procedure in which orders pending were found in the summary immunization table. At that time, the nurse administered vaccines and charted administration online. This updated the online vaccine history.

Rules: The "Pediatric Rules" described below were consistent with the guidelines for childhood immunization approved for January through December 1998 by the Advisory Committee on Immunization practices (ACIP), the American Academy of Pediatrics (AAP) and the American Academy of Family Physicians (AAFP). In many cases the rules were more specific than the guidelines. The rules resulted in a warning to review guidelines for accelerated vaccination when a child was considered behind on immunizations. The national guidelines did not specify exactly when a child should be considered behind. Supplemental parameters were based upon consensus of Pediatric and Family Medicine providers. The "Adult Rules" were consistent with the recommendations of the ACP[2] and the CDC[3].

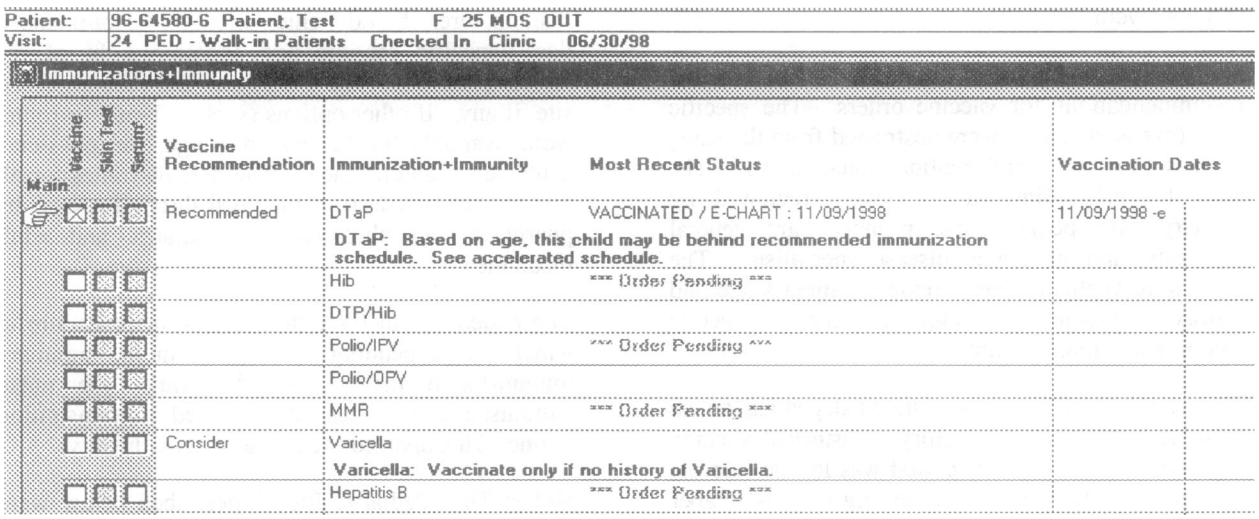
Pediatric Rules (Age less than 17 years)

DTaP: Based upon the number of doses of any vaccine containing Diptheria and Tetanus toxoids, either a) a warning was issued to see guidelines for accelerated vaccination if the patient was older than the age specified in the table below for the number of doses, or b) the age and interval since the most recent dose noted in the table below were evaluated to see if the next dose was recommended.

If Hx of	Warn	Else If Both		Then
	If Age	Age	Interval	Rec.
0 Doses	> 90 d	> 43 d	N/A	Dose 1
1 Dose	> 150 d	N/A	> 42 d	Dose 2
2 Doses	> 240 d	N/A	> 42 d	Dose 3
3 Doses	> 1280 d	N/A	> 180 d	Dose 4
4 Doses	N/A	> 4 yr	> 180 d	Dose 5

Td: This was recommended if at least 11 years old and at least 5 years had past since any Tetanus containing vaccine.

Figure 1. Immunization Reminders



Hepatitis B: Based upon the number of doses of Hepatitis B, the table below was evaluated.

If Hx of	Warn If Age is	Else If Both		Then Rec.
		Age	Interval	
0 Doses	N/A	> 0 d	N/A	Dose 1
1 Dose	N/A	N/A	> 29 d	Dose 2
2 Doses	N/A	N/A	> 119 d	Dose 3

Hib: Based upon the number of doses of any vaccine containing Hib, the table below was evaluated. In this case, if one or more doses was given after the child was over 15 months old, no more doses were recommended.

If Hx of	Warn If Age is	Else If Both		Then Rec.
		Age	Interval	
If age > 5 stop (Hib not recommended)				
0 Doses	> 90 d	> 43 d	N/A	Dose 1
If any dose was given after age 15 mos then stop.				
1 Dose	> 150 d	N/A	> 42 d	Dose 2
2 Doses	> 240 d	N/A	> 42 d	Dose 3
3 Doses	N/A	N/A	> 180 d	Dose 4

MMR: Based upon the number of doses of Measles containing vaccine, the table below was evaluated.

If Hx of	Warn If Age is	Else If Both		Then Rec.
		Age	Interval	
0 Doses	> 4 yr	> 1 yr	N/A	Dose 1
1 Dose	N/A	N/A	> 3 yr	Dose 2

Polio: Based upon the number of doses of any vaccine containing Polio (OPV or IPV), the table below was evaluated. In this case, if a third dose was given after the child was over 4 years old, no more doses were needed and a warning was given that a fourth dose is not recommended. Although a number of options were acceptable, local practice was that doses 1 and 2 were given as IPV while doses 3 and 4 were given as OPV.

If Hx of	Warn If Age is	Else If Both		Then Rec.
		Age	Interval	
0 Doses	> 90 d	> 43 d	N/A	Dose 1
1 Dose	> 150 d	N/A	> 42 d	Dose 2
2 Doses	N/A	N/A	> 42 d	Dose 3
If third dose was given after age 4 then warn/stop.				
3 Doses	> 7 yr	> 4 yr	> 180 d	Dose 4

Varicella: Based upon the number of doses of varicella, the table below was evaluated.

If Hx of	Warn If Age is	Else If Both		Then Rec.
		Age	Interval	
0 Doses	N/A	> 1 yr	N/A	Dose 1
1 Dose	N/A	> 11 yr	> 29 d	Dose 2

Adult Rules (Age greater than or equal to 17)

Hepatitis B was flagged "consider" if patient was a hospital employee or if less than 25 years of age.

Influenza was recommended during October-January and the patient was a hospital employee or was greater than 64.5 years of age

MMR was flagged "consider" if born after 1956 and fewer than 2 doses documented and more than 30 days since most recent dose.

Pneumococcal: This was recommended if age was greater than 64 years (flagged "consider" if more than 63.5 years) and more than 10 years since last received (flagged "consider" if more than 7 years since last received).

Td was recommended if no history of Tetanus vaccine in over 9 years and 6 months.

RESULTS

The patients seen in the FCC over the first six months were grouped by age and service (pediatric ages in Table 1a and adult ages in Table 1b). Residual recommendations (still unresolved recommendations) were assessed at the end of that period. For each group, the percentage with residual recommendations for any vaccine and for specific vaccines were shown.

Table 1a: Number of patients and percentage with recommendations for pediatric age groups. Abbreviations for all tables include: Pn = Pneumococcal vaccine, A = Any vaccine recommendation, Td = Tetanus plus Diphtheria toxoids (adult formulation), HB = Hepatitis B vaccine, PV = Polio Virus vaccine (either inactivated or oral), M = Measles vaccine with or without Mumps and Rubella components, DT = Diptheria and Tetanus (pediatric formulation) with or without a pertussis component, Hi = Haemophilus influenza type b vaccine. Div. = Division; Pts. = patients; Rec. = Recommendations; FM = Family Medicine, GP = General Pediatrics, GM = General Medicine.

Age years	Div.	Pts.	Percent with Residual Rec.					
			A	HB	PV	M	DT	Hi
0-0.5	FM	13	8	8	8	0	8	8
	GP	86	9	9	9	0	9	9
0.5-1.5	FM	54	46	32	30	4	39	39
	GP	330	52	42	32	6	42	42
1.5-6	FM	209	92	77	68	63	86	75
	GP	989	70	48	43	47	63	47
6-16	FM	484	96	92	90	87	10	0
	GP	1031	78	64	64	58	13	0
	GM	7	86	86	86	86	0	0

Table 1b: Number of patients and percentage with recommendations for adult ages.

Age yrs	Div.	Pts.	Percent with Residual Rec.					
			A	Pn	Td	HB	PV	M
16-45	FM	2939	92	0	91	5	3	3
	GP	151	85	0	60	41	34	34
	GM	2794	87	0	86	2	0	0
45-65	FM	1029	94	1	93	1	0	0
	GM	2617	76	2	76	1	0	0
>65	FM	339	98	88	94	0	0	0
	GM	1494	84	61	78	1	0	0

Data on residual recommendations were also compared for patients whose most recent visit was in the first three months ("First") with patients whose most recent visit was in the second three months ("Second") of operation (Table 2). For each vaccine we compared the proportion of patients with residual recommendations ("Yes") versus no recommendations ("No"). Chi-square 2x2 contingency analysis was used to assess the P values.

Table 2: Comparison of proportions of patients with or without residual recommendations for patients most recently seen during the first three months versus the second three months.

	First		Second		
	Recommendations				P <
	Yes	No	Yes	No	
Any	4530	766	7631	1642	0.0001
Pn	442	4854	808	8465	0.465
Td	3913	1383	6542	2731	0.0001
HB	923	4373	1283	7990	0.0001
PV	825	4471	1121	8152	0.0001
M	759	4537	1034	8239	0.0001
DT	436	4860	724	8549	0.379
Hib	303	4993	484	8789	0.211

Treating the reduction of residual recommendations or warnings as a benefit, Table 3 shows the relative benefit (RB) comparing the second with the first period for each vaccine group and each service. Only those RB associated with P < .0001 were shown. Except for the case of pneumococcal vaccine in General Medicine, in which case the P value was 0.0129 for a relative benefit of only 1.04, the other RB not shown were clearly not significant, with P values well above 0.05.

Table 3: Relative benefit comparing the second three months with the first three as a baseline.

	Relative Benefits where P < 0.0001			
	All	FM	GP	GM
Any	1.22		1.37	1.30
Pn				
Td	1.13		1.13	1.31
HB	1.04		1.27	
PV	1.04		1.26	
M	1.04		1.20	
DT				
Hib				

DISCUSSION

We presented algorithms for following national vaccine guidelines, as has been done previously[5]. A multi-component tool used online documentation systems for assessing vaccine compliance and making recommendations, also the subject of other reports[6]. The main purpose of the system was quality assessment and promotion[7-9]. The system made it much easier to track these quality measures for the entire population.

Overwhelmingly, the biggest single contributor to residual recommendations was adult tetanus vaccine (Td) with 71.8 % of patients' histories suggesting they were out of compliance. At the other end of the spectrum were the vaccines of most importance the youngest patients, DTaP, Hib, and Polio. Adult vaccine compliance was disappointingly poor overall. The only ray of hope was that in General Medicine, the trend from first period to second suggested a small but significant improvement in compliance.

The data demonstrated high percentages of patients for whom the rules generated some recommendation. In most cases, it was because the history indicated that the patient was out of compliance with guidelines. For the pediatric population between 0 and 6 years of age, there were wide windows of opportunity when a vaccine was recommended but before the patient was out of compliance. In that age range, 33% of the recommendations made were during the window of compliance (data not shown). The remainder (67%) indicated that the patients were behind on immunizations.

We made every attempt to ensure an accurate online history, including review of billing records and of the page in the paper record that was supposed to contain the summary of immunization history. Other information may have existed in the paper record so that it was difficult to find. In such cases, only the primary care physician thoroughly familiar with the patient knew the entire history. Thus, the system issued recommendations in some circumstances in which a clinician could judge that no action was needed. We do not claim to show that there was a large number of patients out of compliance. We found a prevalent problem that it was difficult to demonstrate compliance in a large fraction of patients based upon data that were easily found in the record. The application reported here was intended to alleviate that problem.

For this reason, we focused not on the apparent proportions in compliance, but on improvements experienced between the first and second periods. Overall, there was a highly statistically significant 22% improvement in the number of patients with no residual vaccine recommendations, indicating compliance with national guidelines. Patients whose most recent visit was during the second period had a higher average number of visits to the FCC (2.4 visits) than did those whose most recent visit was in the first period (1.4 visits). Those in the former group would have had more opportunities to have their online histories updated. In addition, they would have had more opportunities for their providers to act on recommendations and bring the patients into compliance. Interpreting this improvement depended on whether the improvement was in the completeness of the data or was in medical practice. This cannot be determined from the data in this report.

The comparison between periods was used only to demonstrate improvements in readily available evidence for compliance. We conclude that the immunization application is alleviating this major problem as intended.

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